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(54) **ARTICLE, AIRFOIL COMPONENT AND METHOD FOR FORMING ARTICLE**

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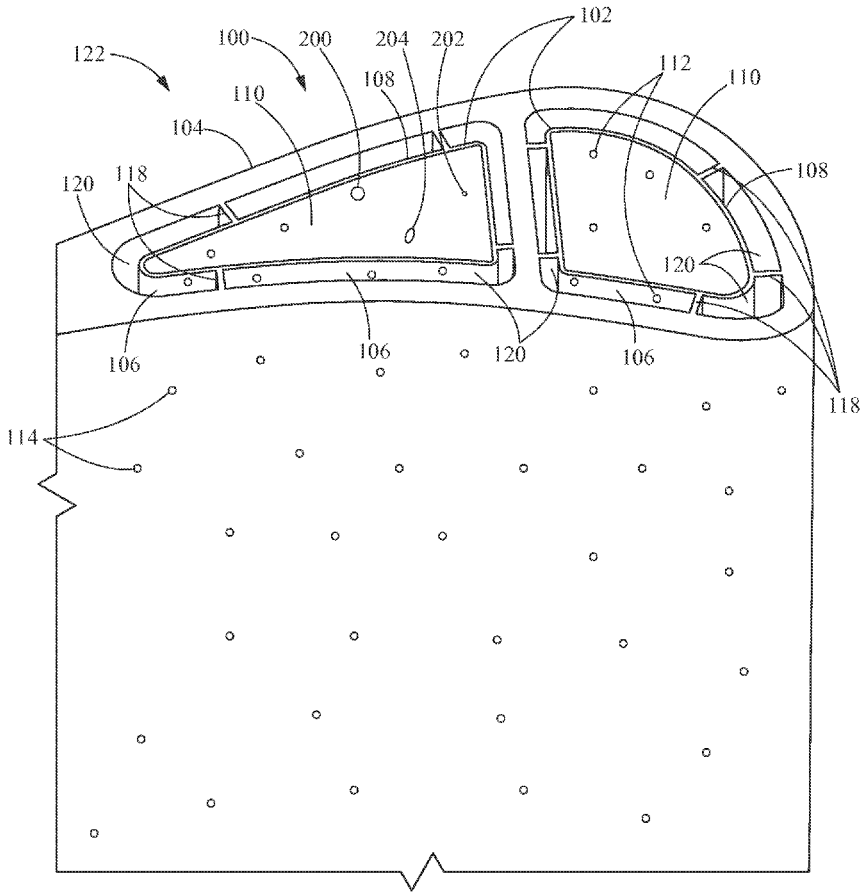
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(57) **ABSTRACT**

An article is disclosed including a manifold, an article wall, a post-impingement cavity and a plurality of post-impingement partitions. The manifold includes an impingement wall defining a plenum and a plurality of impingement apertures. The article wall includes a plurality of external apertures. The post-impingement cavity is disposed between the manifold and the article wall, and is arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures. The plurality of post-impingement partitions divide the post-impingement cavity into a plurality of sub-cavities, and hermetically separate the plurality of sub-cavities from one another. The impingement wall, article wall and plurality of post-impingement partitions are integrally formed as a single, continuous article. The article may be an airfoil component. A method for forming the article includes forming a single, continuous object by an additive manufacturing technique.



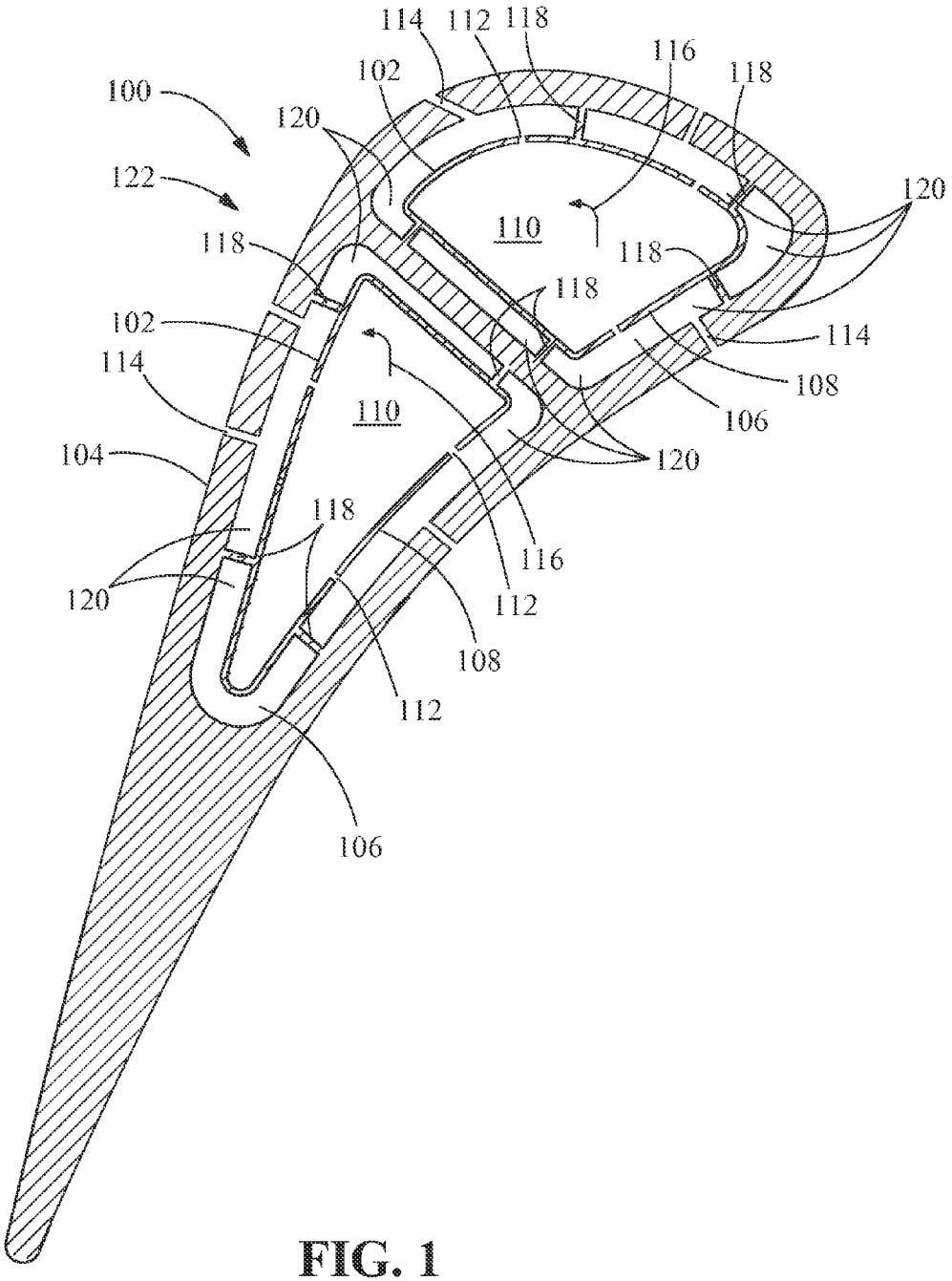

114
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FIG. 1

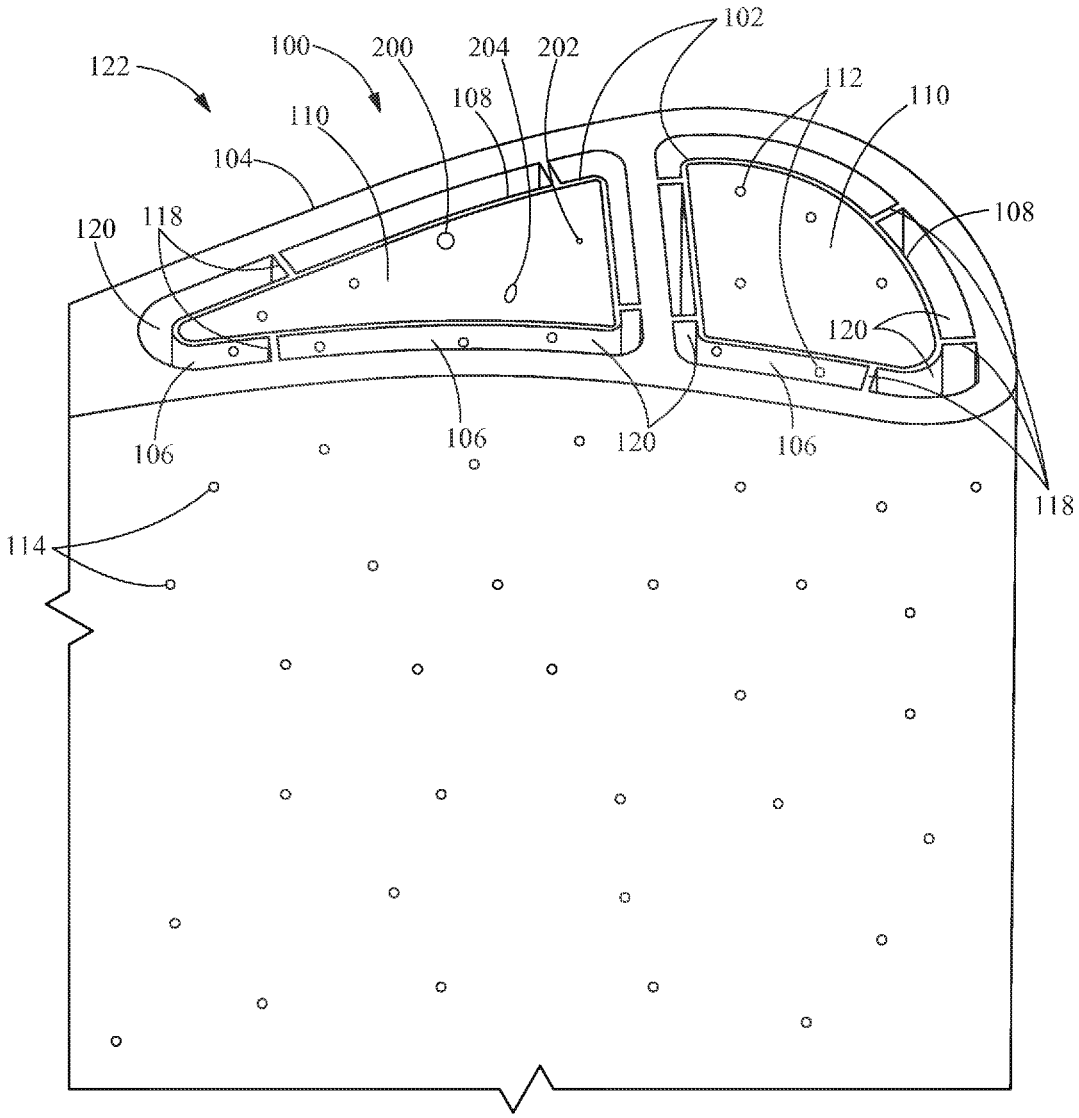

122
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FIG. 2

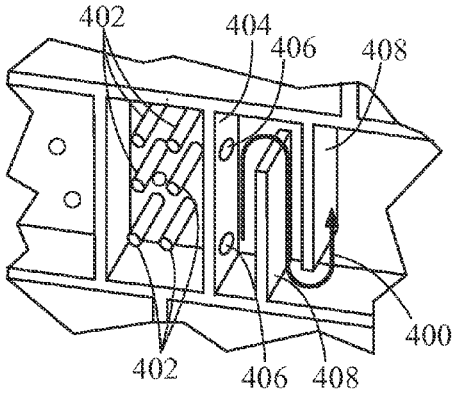

402
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FIG. 4

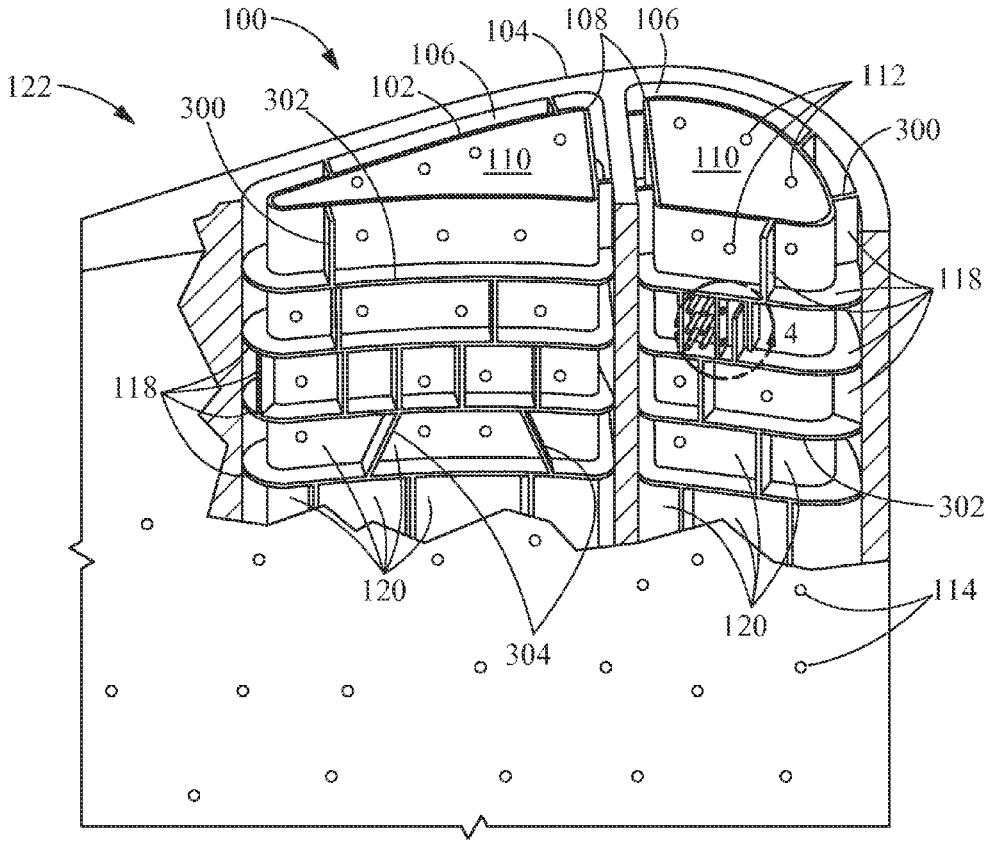

100
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4
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FIG. 3

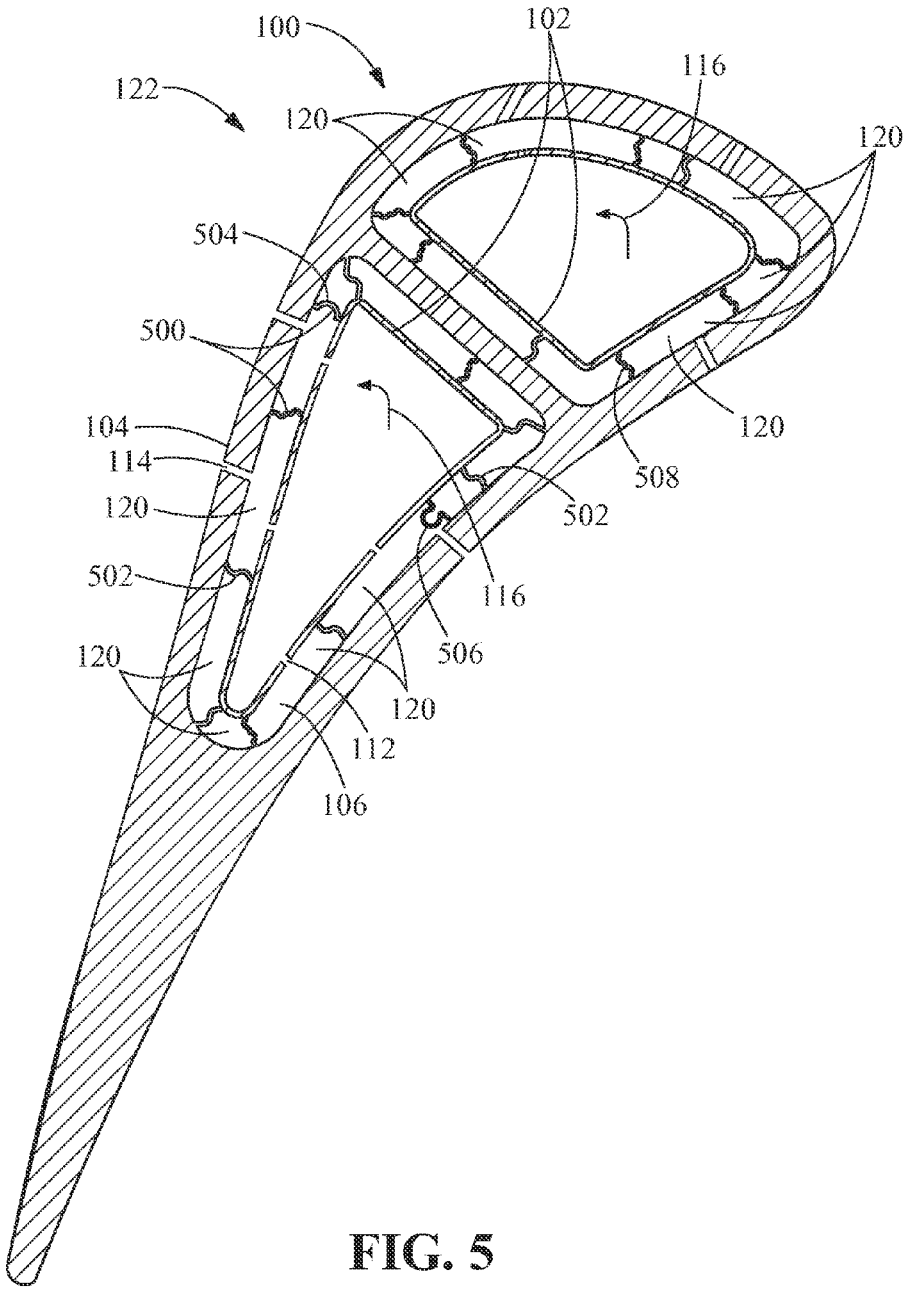

100
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508

FIG. 5

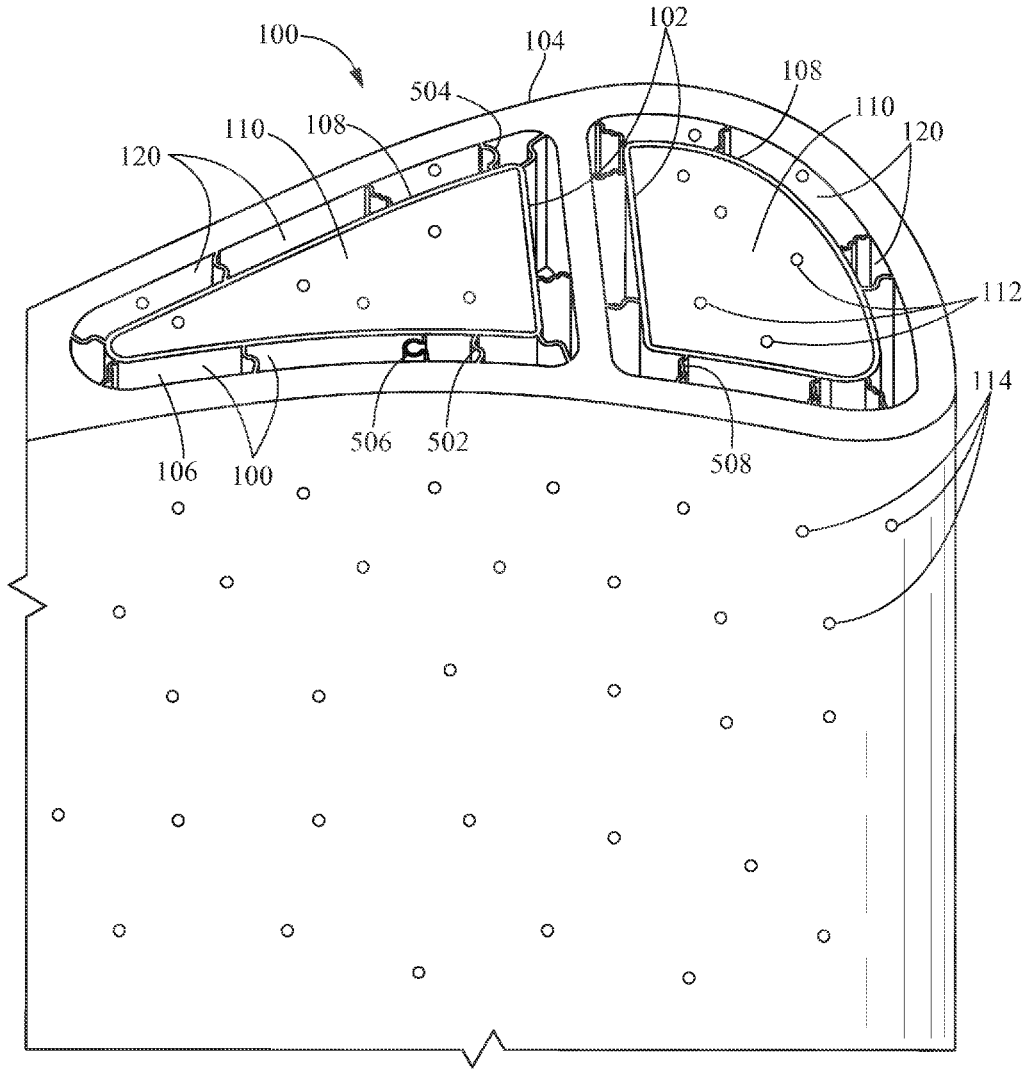


FIG. 6

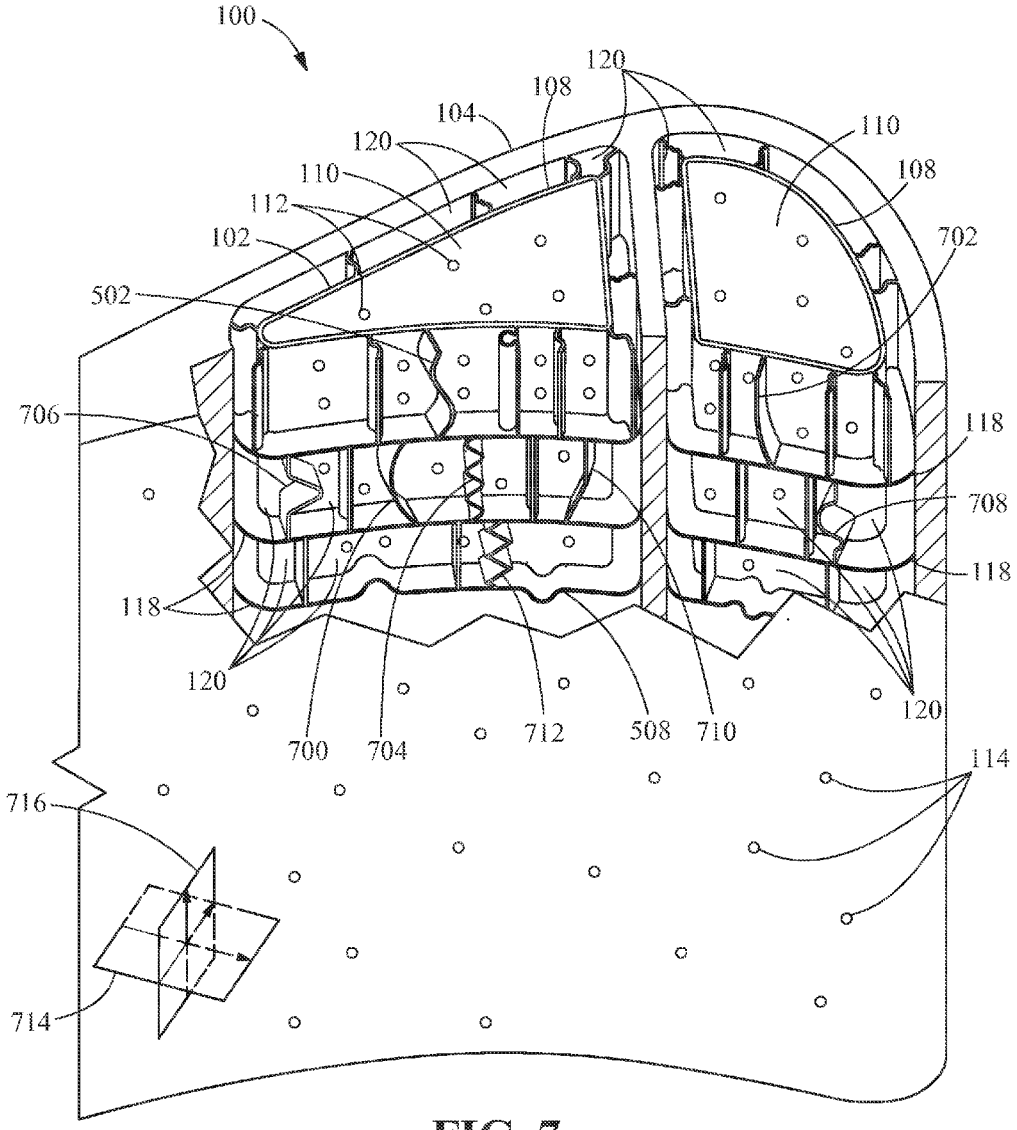

100
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700
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712
508
710
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114
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714

FIG. 7

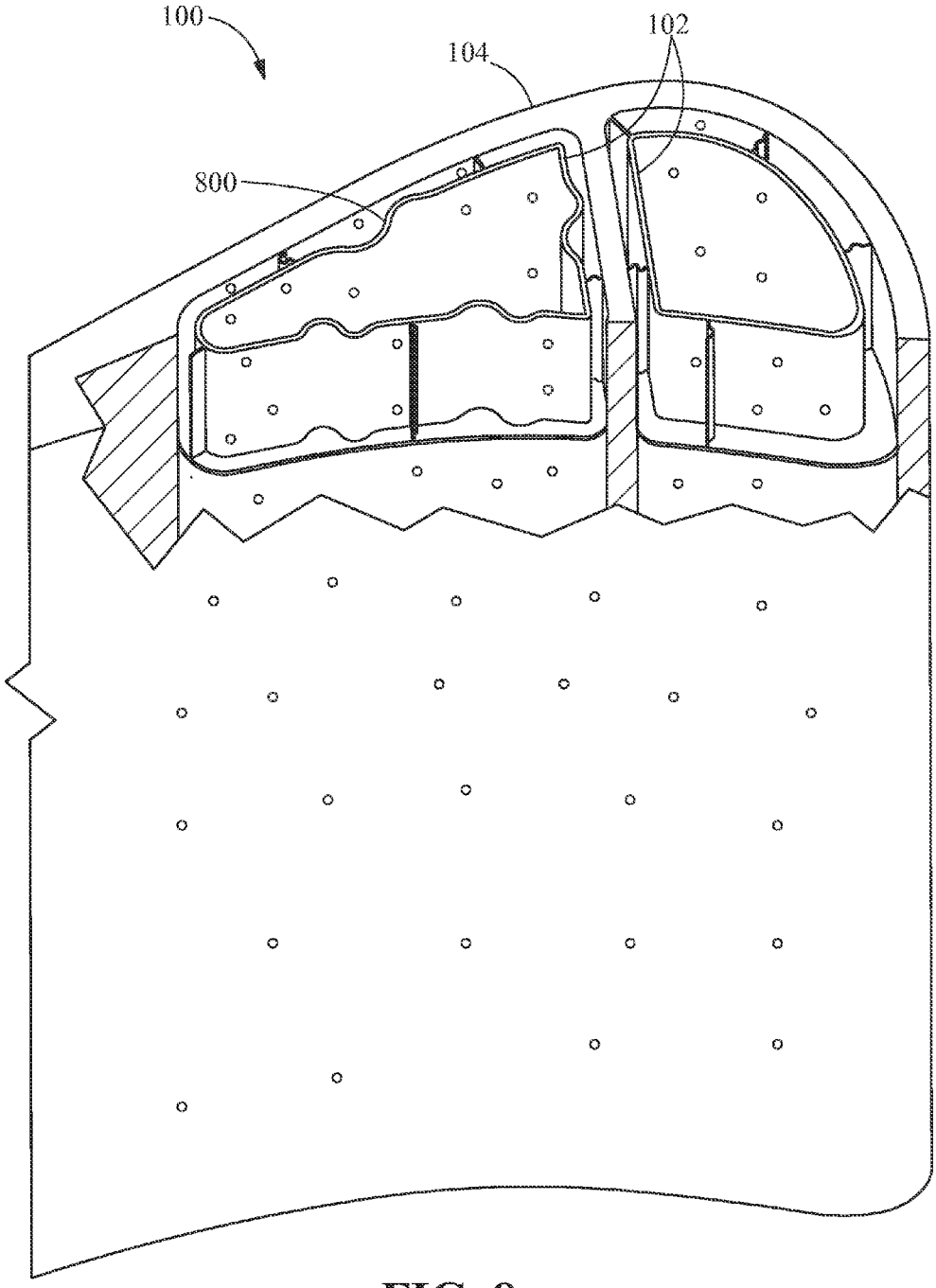


FIG. 8

ARTICLE, AIRFOIL COMPONENT AND METHOD FOR FORMING ARTICLE

FIELD OF THE INVENTION

[0001] The present invention is directed to articles and methods for forming articles. More particularly, the present invention is directed to articles integrally formed as single, continuous articles and methods for forming the articles employing additive manufacturing techniques.

BACKGROUND OF THE INVENTION

[0002] Gas turbines airfoils such as nozzles are subjected to intense heat and external pressures in the hot gas path. These rigorous operating conditions are exacerbated by advances in the technology, which may include both increased operating temperatures and greater hot gas path pressures. As a result, gas turbine nozzles are sometimes cooled by flowing a fluid through a manifold inserted into the core of the nozzle, which exits the manifold through impingement holes into a post-impingement cavity, and which then exits the post-impingement cavity through apertures in exterior wall of the nozzle, forming a film layer of the fluid on the exterior of the nozzle.

[0003] However, flowing the fluid through the manifold in a sufficient volume to cool the entire nozzle decreases efficiency of the gas turbine due to the need to maintain a sufficiently high back-flow margin (post-impingement pressure relative to the gas path pressure) at every external aperture, and to overcome crossflow in the post-impingement cavity. Attempts to divide the post-impingement cavity for better flow control have been inhibited by significant fluid leakage between sub-divided portions at operating conditions, and further, sub-dividing structures may be adversely affected by differential heat expansion and mechanical stresses from turbine operation.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In an exemplary embodiment, an article includes a manifold, an article wall, a post-impingement cavity and a plurality of post-impingement partitions. The manifold includes an impingement wall defining a plenum and a plurality of impingement apertures. The article wall includes a plurality of external apertures. The post-impingement cavity is disposed between the manifold and the article wall, and is arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures. The plurality of post-impingement partitions divide the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another. The impingement wall, article wall and plurality of post-impingement partitions are integrally formed as a single, continuous article.

[0005] In another exemplary embodiment, an airfoil component includes a manifold, an airfoil wall, a post-impingement cavity and a plurality of post-impingement partition. The manifold includes an impingement wall defining a plenum and a plurality of impingement apertures. The airfoil wall includes a plurality of external apertures. The post-impingement cavity is disposed between the manifold and the airfoil wall, and is arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures. The plurality of post-impingement partitions divide the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another. The impingement wall, airfoil wall and plurality of post-impingement partitions are integrally formed as a single, continuous article.

[0006] In another exemplary embodiment, a method for forming an article includes forming a single, continuous object by an additive manufacturing technique, the single, continuous object including a manifold, an article wall, a post-impingement cavity and a plurality of post-impingement partitions. The manifold includes an impingement wall defining a plenum and a plurality of impingement apertures. The article wall includes a plurality of external apertures. The post-impingement cavity is disposed between the manifold and the article wall, and is arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures. The plurality of post-impingement partitions divide the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another.

[0007] Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a cross-sectional view of an article, according to an embodiment of the present disclosure.

[0009] FIG. **2** is a perspective view of the article of FIG. **1**, according to an embodiment of the present disclosure.

[0010] FIG. **3** is a cut-away perspective view of the article of FIG. **1**, according to another embodiment of the present disclosure.

[0011] FIG. **4** is an expanded view of the cut-away perspective view of FIG. **3**, according to another embodiment of the present disclosure.

[0012] FIG. **5** is a cross-sectional view of an article, according to another embodiment of the present disclosure.

[0013] FIG. **6** is a perspective view of the article of FIG. **5**, according to an embodiment of the present disclosure.

[0014] FIG. **7** is a cut-away perspective view of the article of FIG. **5**, according to another embodiment of the present disclosure.

[0015] FIG. **8** is a cut-away perspective view of an article, according to yet another embodiment of the present disclosure.

[0016] Wherever possible, the same reference numbers will be used throughout the drawings to represent the same parts.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Provided are exemplary articles, airfoil components and methods of forming articles and airfoil component. Embodiments of the present disclosure, in comparison to articles and methods not utilizing one or more features disclosed herein, better accommodate differential thermal expansion, increase tolerance of aerodynamic loads,

improve cooling, improve durability, increase efficiency, improve sealing between the impingement walls and article walls, improve local back flow margin, improve film effectiveness and improve manufacturability of complex structures.

[0018] Referring to FIG. **1**, in one embodiment an article **100** includes a manifold **102**, an article wall **104** and a post-impingement cavity **106**, the post-impingement cavity **106** being disposed between the manifold **102** and the article wall **104**. The manifold **102** includes an impingement wall **108** defining a plenum **110** and a plurality of impingement apertures **112**. The article wall **104** includes a plurality of external apertures **114**. The post-impingement cavity **106** is arranged to receive a fluid **116** from the plenum **110** through the plurality of impingement apertures **112** and exhaust the fluid **116** through the plurality of external apertures **114**. A plurality of post-impingement partitions **118** divide the post-impingement cavity **106** into a plurality of sub-cavities **120**, the plurality of post-impingement partitions **118** hermetically separating the plurality of sub-cavities **120** from one another. The impingement wall **108**, article wall **104** and plurality of post-impingement partitions **118** are integrally formed as a single, continuous article.

[0019] As used herein, "hermetically separating" indicates that the plurality of sub-cavities **120** are isolated from one another such that the fluid **116** cannot flow directly from one of the plurality of sub-cavities **120** to another of the plurality of sub-cavities. "Hermetically separating" the plurality of sub-cavities **120** does not in any way preclude that more than one of the plurality of sub-cavities **120** may be in fluid communication with the same plenum **110** through the plurality of impingement aperture **112**, or with the hot gas path through the plurality of external apertures **114**.

[0020] The hermetically separated plurality of sub-cavities **120** may reduce or eliminate cross flow of the fluid **116** in the post-impingement cavity **106**. As used herein, "cross-flow" refers to fluid **116** which flows with inhibited thermal contact with the article wall **104**, or which is inhibited from exhausting through a particular external aperture **114** due to the fluid dynamics of the post-impingement cavity. In one embodiment, after the fluid **116** passes through one of the plurality of impingement apertures **112**, the fluid **116** impinges on the article wall **104** and flows along one of the plurality of sub-cavities **120** until it reaches and exhausts through one of the plurality of external apertures **114**. The plurality of post-impingement partitions which hermetically separate the sub-cavity **120** from the surrounding plurality of sub-cavities **120** prevent the fluid **116** from disrupting and being disrupted by cross flow from upstream jets of the fluid **116** passing through others of the plurality of impingement apertures **112**, maintaining the cooling effectiveness of both the upstream fluid **116** and the downstream jets of the fluid **116**. The plurality of post-impingement partitions **118** may be disposed and arranged so as to direct flow of the fluid **116** along the article wall **104** in the plurality of sub-cavities **120** so as to reduce cross flow disruption on heat transfer coefficients in regions of the article **100** sensitive to elevated temperatures in comparison to comparable articles lacking the plurality of post-impingement partitions **118**.

[0021] In one embodiment, the article **100** may be any suitable turbine component, including, but not limited to, an airfoil **122** (shown), a bucket (blade), a nozzle (vane), a shroud, or a combination thereof.

[0022] In one embodiment, a method for forming an article **100** includes employing an additive manufacturing technique to integrally form the impingement wall **108**, the article wall **104** and the plurality of post-impingement partitions **118** as a single, continuous object. The additive manufacturing technique may include any suitable technique, including, but not limited to, direct metal laser melting, direct metal laser sintering, selective laser melting, selective laser sintering, electron beam melting, laser metal deposition, or combinations thereof.

[0023] Referring to FIG. **2**, in one embodiment, the impingement wall **108** includes an arrangement and conformations of the plurality of impingement apertures **112** to distribute the fluid **116** to generate a higher heat transfer coefficient in a sub-cavity **120** exposed to higher temperatures as compared to a sub-cavity **120** exposed to a lower temperatures. The conformations of the impingement apertures **112** may include larger cross-sectional areas **200**, smaller cross-sectional areas **202**, non-circular conformations **204**, or combinations thereof to optimize the distribution of the fluid **116**. In a further embodiment, regions of the article **100** subjected to increased temperatures relative to other regions of the article **100** include a greater concentration of impingement apertures **112**, impingement apertures **112** having larger cross-sectional areas **200**, or both, to increase the impingement pressure, and, hence, optimize the temperature moderation effect of the fluid across the article **100**.

[0024] In another embodiment, the impingement wall **108** and the article wall **104** include an arrangement and conformations of the plurality of impingement apertures **112** and the plurality of external apertures **114** to distribute the fluid **116** to generate a positive back-flow margin across each external aperture **114**. In yet another embodiment, the hot gas path pressure varies along the external surface of the article **100**, including, but not limited to, where the article **100** is an airfoil **122**, and the pressure of each of the plurality of sub-cavities **120** is varied correspondingly so as to be greater than the hot gas path pressure at each external aperture **114**. Sub-cavities **120** exhausting the fluid **116** through external apertures **114** where the hot gas path pressure is reduced may be optimized to have a lower pressure in the sub-cavities **120** while still maintaining a pressure in excess of the hot gas path pressure at the external apertures **114**, thereby having an increased pressure drop across the corresponding impingement apertures **112** and having increased local cooling effectiveness.

[0025] Referring to FIG. **3**, in one embodiment, the plurality of post-impingement partitions **118** have any suitable orientation, including, but not limited to, vertical partitions **300**, horizontal partitions **302**, and diagonal partitions **304**. As used herein, "vertical", "horizontal" and "diagonal" reference the general orientation of a post-impingement partition **118** with respect to the article **100**, and do not necessitate or imply a linear conformation for the post-impingement partition **118**. Inclusion of vertical partitions **300**, horizontal partitions **302**, diagonal partitions **304**, or combinations thereof, facilitates the optimization of the flow of the fluid **116** through the post-impingement cavity **106** and through the plurality of external apertures **114** based on the anticipated ranges of temperature and hot gas path pressure over varying areas of the article **100** during operating conditions.

[0026] Referring to FIG. **4**, in one embodiment, the plurality of sub-cavities **120** include features for modifying the post impingement flow path **400** of the fluid. Such features include, but are not limited to, turbulators (including, but not limited to, pin banks or pedestals) **402**, dividers **404** having flow restriction apertures **406**, sequenced partial dividers **408** establishing a serpentine post impingement flow path **400**, and combinations thereof. These features may further reduce or eliminate crossflow in the post-impingement cavity **106**.

[0027] Referring to FIGS. **5-7**, in one embodiment, the plurality of post-impingement partitions **118** include a non-linear conformation **500**. Non-linear conformations **500** included, but are not limited to, s-shaped **502**, c-shaped **504**, omega-shaped **506**, undulating **508**, curved **700**, partially curved **702**, sinusoidal **704**, Gaussian **706**, asymmetrically curved **708**, deflected **710**, zigzagging **712**, and combinations thereof. The non-linear conformation **500** of a post-impingement partition **118** may be non-linear with respect to the horizontal plane **714**, the vertical plane **716** or both.

[0028] In a further embodiment, the non-linear conformation **500** of the plurality of post-impingement partitions **118** provides a flexible attachment of the manifold **102** to the article wall **104**. The flexible attachment of the manifold **102** to the article wall **104** may accommodate differential thermal expansion, absorb mechanical stresses, or both.

[0029] Referring to FIG. **8**, in one embodiment, the impingement wall **108** includes a wall non-linear conformation **800**. The wall non-linear conformation **800** may accommodate differential expansion, absorb mechanical stresses, or both.

[0030] While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. An article, comprising:

a manifold including an impingement wall, the impingement wall defining a plenum and a plurality of impingement apertures;

an article wall including a plurality of external apertures;

a post-impingement cavity disposed between the manifold and the article wall, the post-impingement cavity arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures; and

a plurality of post-impingement partitions dividing the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another,

wherein the impingement wall, article wall and plurality of post-impingement partitions are integrally formed as a single, continuous article.

2. The article of claim **1**, wherein the article is an airfoil.

3. The article of claim **1**, wherein the plurality of impingement apertures are arranged and conformed to distribute the fluid to generate a higher heat transfer coefficient in a sub-cavity exposed to higher temperatures as compared to a sub-cavity exposed to a lower temperatures.

4. The article of claim **1**, wherein the plurality of impingement apertures and the plurality of external apertures are arranged and conformed to distribute the fluid to generate a positive back-flow margin across each external aperture.

5. The article of claim **1**, wherein the plurality of post-impingement partitions include a non-linear conformation.

6. The article of claim **1**, wherein the impingement wall includes a non-linear conformation.

7. The article of claim **1**, wherein the plurality of sub-cavities include features selected from the group consisting of turbulators, dividers having flow restriction apertures, sequenced partial dividers establishing a serpentine flow path, and combinations thereof.

8. An airfoil component, comprising:

a manifold including an impingement wall, the impingement wall defining a plenum and a plurality of impingement apertures;

an airfoil wall including a plurality of external apertures;

a post-impingement cavity disposed between the manifold and the airfoil wall, the post-impingement cavity arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures; and

a plurality of post-impingement partitions dividing the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another,

wherein the impingement wall, airfoil wall and plurality of post-impingement partitions are integrally formed as a single, continuous article.

9. The component of claim **8**, wherein the plurality of impingement apertures are arranged and conformed to distribute the fluid to generate a higher heat transfer coefficient in a sub-cavity exposed to higher temperatures as compared to a sub-cavity exposed to a lower temperatures.

10. The component of claim **8**, wherein the plurality of impingement apertures and the plurality of external apertures are arranged and conformed to distribute the fluid to generate a positive back-flow margin across each external aperture.

11. The component of claim **8**, wherein the plurality of post-impingement partitions include a non-linear conformation.

12. The component of claim **8**, wherein the impingement wall includes a non-linear conformation.

13. The component of claim **8**, wherein the plurality of sub-cavities include features selected from the group consisting of turbulators, dividers having flow restriction apertures, sequenced partial dividers establishing a serpentine flow path, and combinations thereof.

14. A method for forming an article, comprising forming a single, continuous object by an additive manufacturing technique, the single continuous object including:

a manifold including an impingement wall, the impingement wall defining a plenum and a plurality of impingement apertures;

an article wall including a plurality of external apertures;

a post-impingement cavity disposed between the manifold and the article wall, the post-impingement cavity arranged to receive a fluid from the plenum through the plurality of impingement apertures and exhaust the fluid through the plurality of external apertures; and

a plurality of post-impingement partitions dividing the post-impingement cavity into a plurality of sub-cavities, the plurality of post-impingement partitions hermetically separating the plurality of sub-cavities from one another.

15. The method of claim **14**, wherein the article is an airfoil.

16. The method of claim **14**, wherein the additive manufacturing technique is selected from the group consisting of direct metal laser melting, direct metal laser sintering, selective laser melting, selective laser sintering, electron beam melting, laser metal deposition, and combinations thereof.

17. The method of claim **14**, wherein the plurality of impingement apertures are arranged and conformed to distribute the fluid to generate a higher heat transfer coefficient in a sub-cavity exposed to higher temperatures as compared to a sub-cavity exposed to a lower temperatures.

18. The method of claim **14**, wherein the plurality of impingement apertures and the plurality of external apertures are arranged and conformed to distribute the fluid to generate a positive back-flow margin across each external aperture.

19. The method of claim **14**, wherein at least one of the impingement wall and the plurality of post-impingement partitions includes a non-linear conformation.

20. The method of claim **14**, wherein the plurality of sub-cavities include features selected from the group consisting of turbulators, dividers having flow restriction apertures, sequenced partial dividers establishing a serpentine flow path, and combinations thereof.

* * * * *